

# Highway Noise Levels in a Suburban Environment Under Inversion Conditions

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# Presentation conducted by Hugh Saurenman for James Chambers

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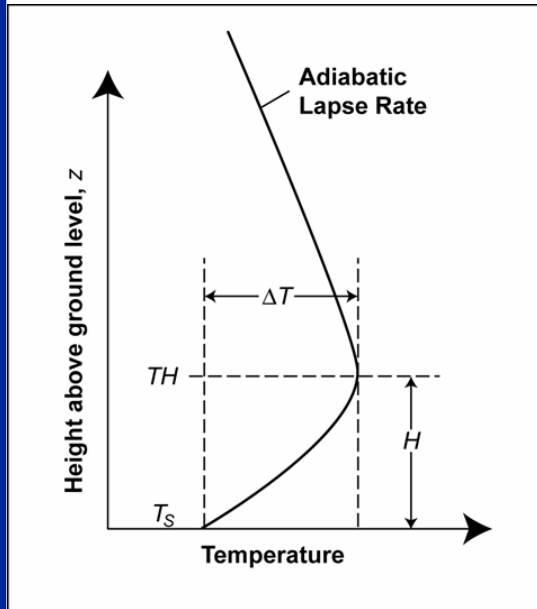
## Parabolic Equation Model (PE)

- Full wave solution of wave equation
- Multiple varieties available
  - Split step solution (propagate in uniform atmosphere then correct for atmospheric effects)
  - Requires small steps, constant freq.
  - Can handle arbitrary atmosphere and ground impedance
  - Needs temperature and wind profile to ~10-20% prop range
- Topography changes (barriers, terrain, etc.) open research area

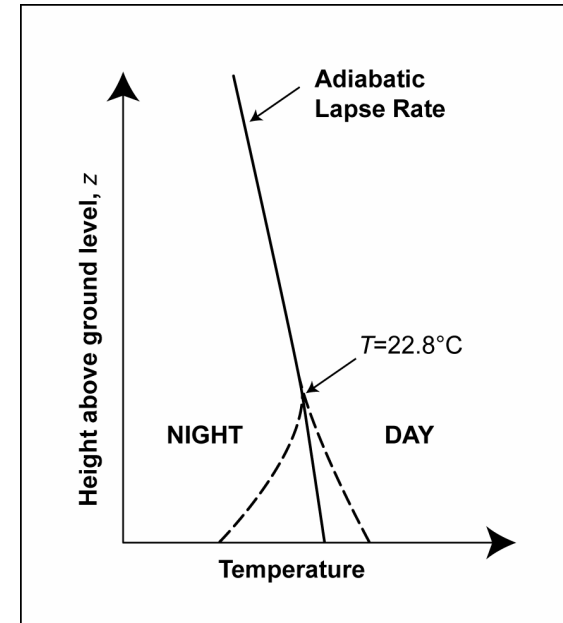


# MET MODELING (temperature)

## 50' tower site 2



Stull's Scaling  
Law



$$T(z) = T_s + [1 - (1 - z/H)^{\alpha}] \Delta T$$

$$dT/dz = \Delta T \alpha / H @ z = 0$$

Assumptions:

$$\alpha = 2.5$$

$$\Delta T = 22.8^{\circ} \pm T_s$$

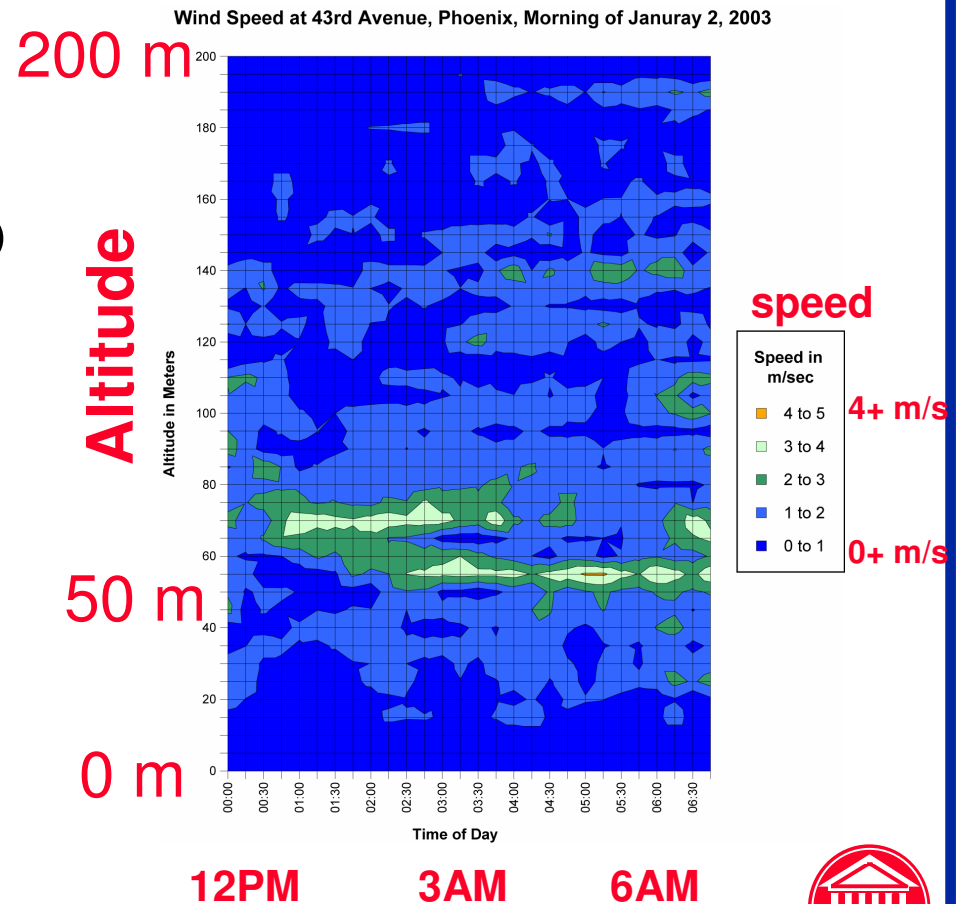
$$dT/dz = \text{measured}$$



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# MET MODELING (wind)

- No significant winds measured up to 13 m (50')
- Previous Arizona Department of Environmental Quality (ADEQ) suggested low level “jet” of 2-4 m/s at ~50m at site several miles away
- Representative wind profile used to see representative effects

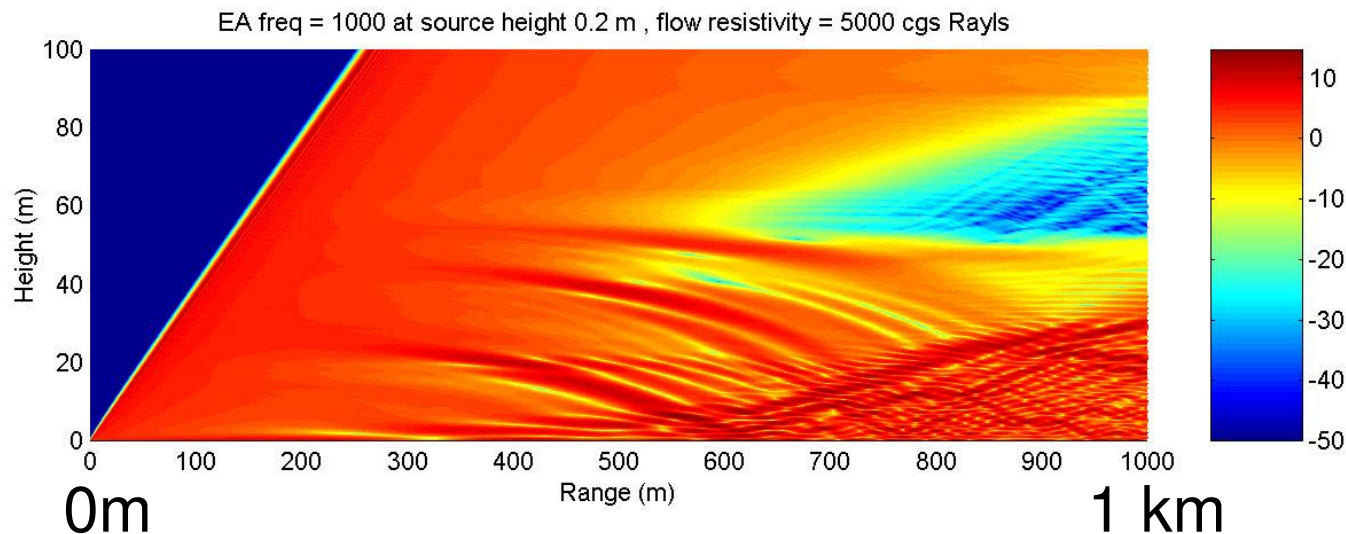
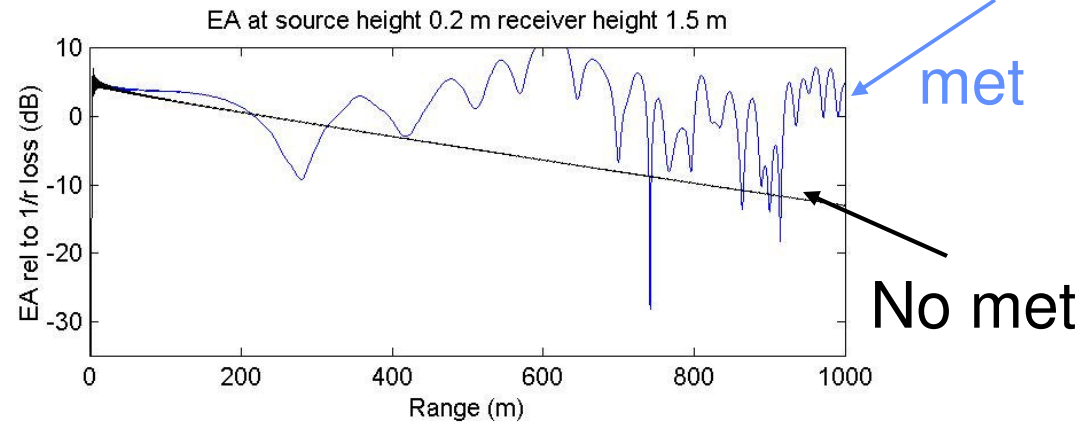
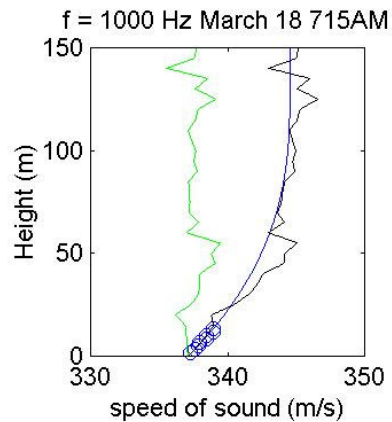


## PE RESULTS CONTINUED

- PE run for octave bands 63Hz to 1 kHz
- PE run for no met (air absorption and ground absorption) as reference
  - rh from met data,  $\sigma = 5000$  cgs rayls (assumed)
- PE run for temperature only as well as temperature combined with upwind and downwind
- Site 1 level used as source and range corrected (along with PE output) to predict levels in neighborhood (sites 3-4).

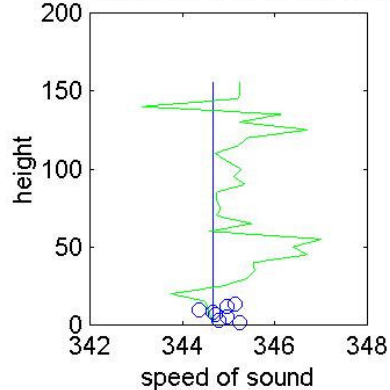


# PE RESULTS (freq = 1kHz, temp + wind)

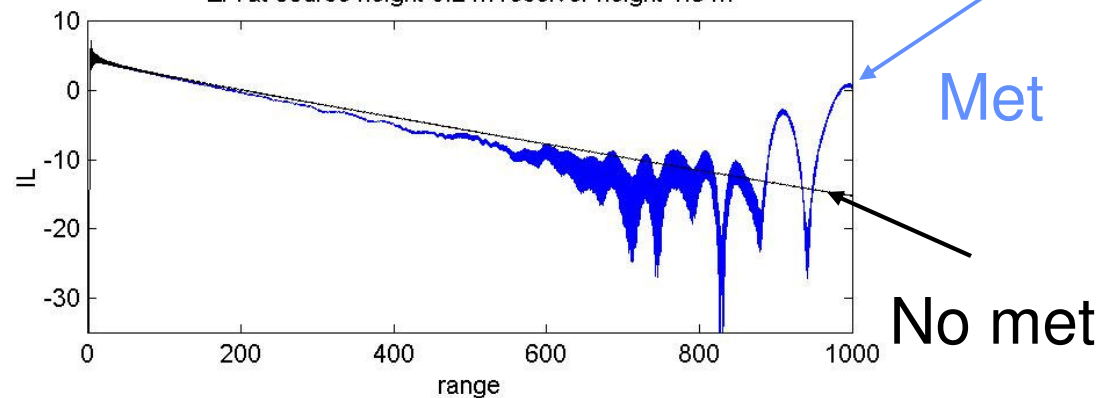


# PE RESULTS (freq = 1kHz, wind only)

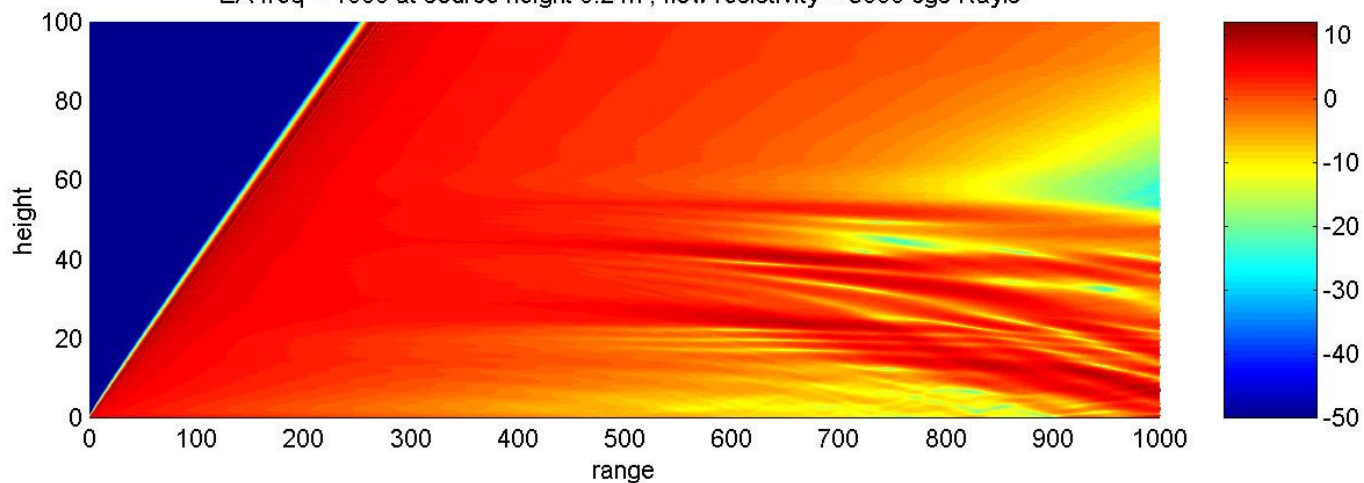
f = 1000 Hz March 18th 915 AM



EA at source height 0.2 m receiver height 1.5 m

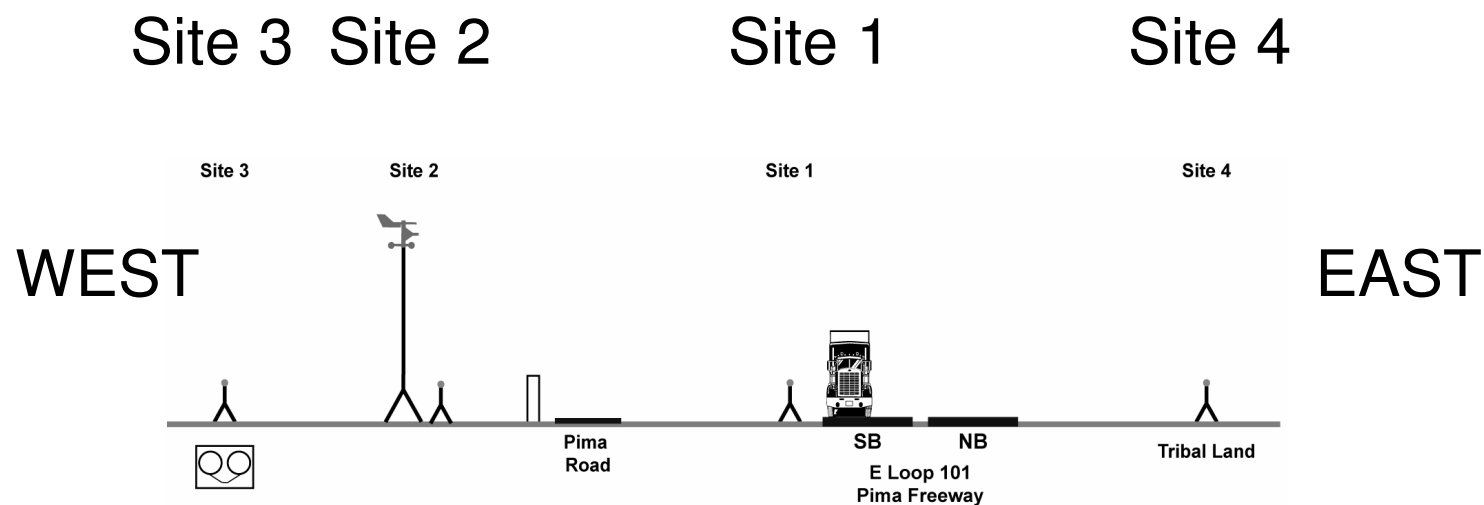


EA freq = 1000 at source height 0.2 m , flow resistivity = 5000 cgs Rayls





# FIELD MEASUREMENTS



1/3 octave band  
recordings

13m (50') met tower



**Noise Monitors:** Larson Davis 824s. Data loggers used at Sites 2 and 3 for continuous collection of 1/3 octave band data at one second intervals.



**Met Station:** 13.7 m (45 ft) tower, wind speed and direction at 13.7 m (45 ft) and ground level, temperature at 1.7 m (5.5 ft) intervals, humidity at ground level.



**Digital Audio Recorder:** Continuous audio recording saving 15 minute WAV files on a hard drive.



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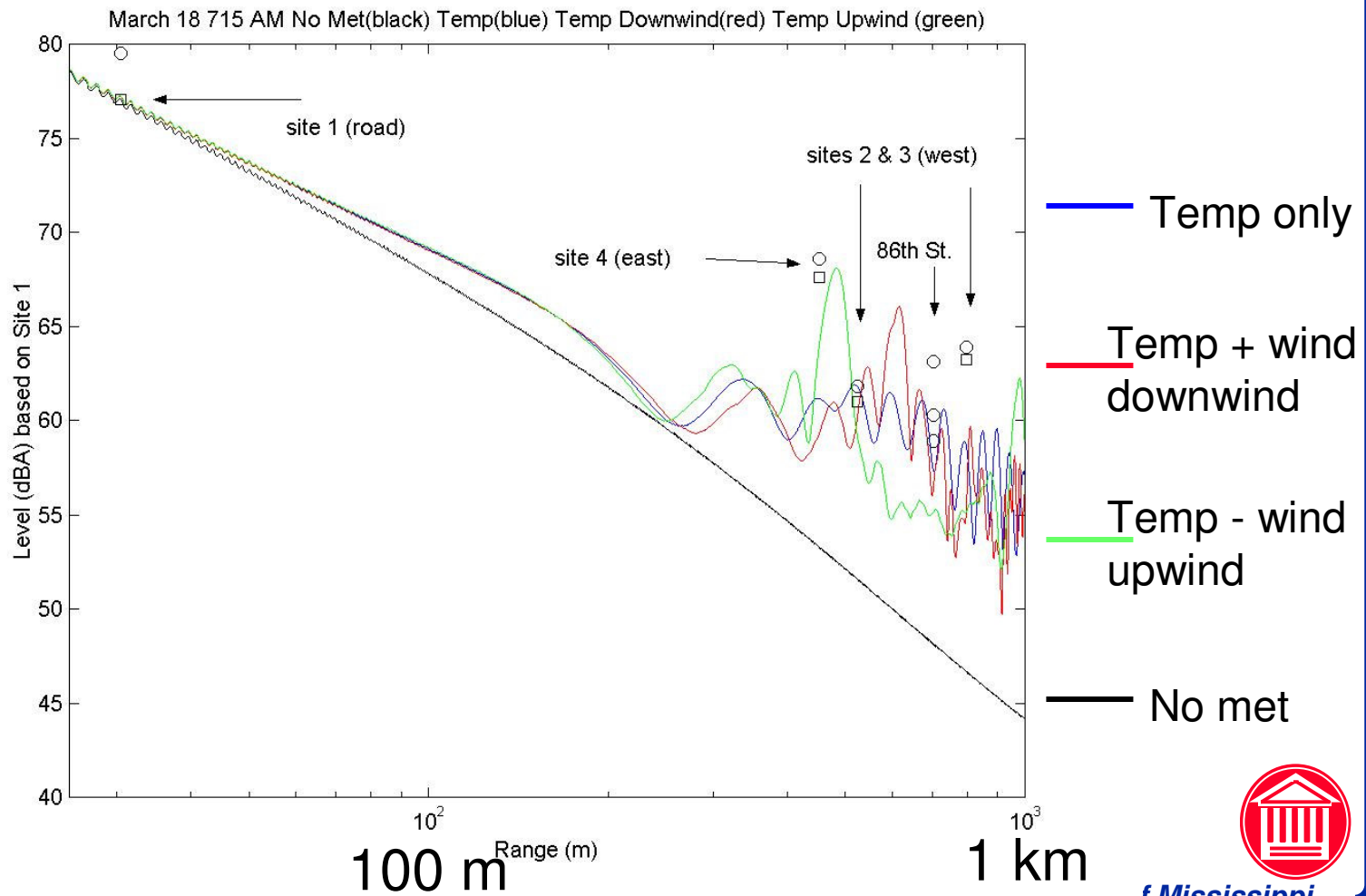
## Predicting Levels

- PE code provides Excess Attenuation (relative to spreading loss), need to correct “source” level
- Site 1 used as quasi-source and then range corrected for sites 2-4
- Usually assumes point source ( $1/r$  or  $20 \log_{10}(\text{range})$ )
- Long highway (or infinite line) source  $1/\sqrt{r}$  or  $10 \log_{10}(\text{range})$
- Our data seems to split the difference  $15 \log_{10}(\text{range})$

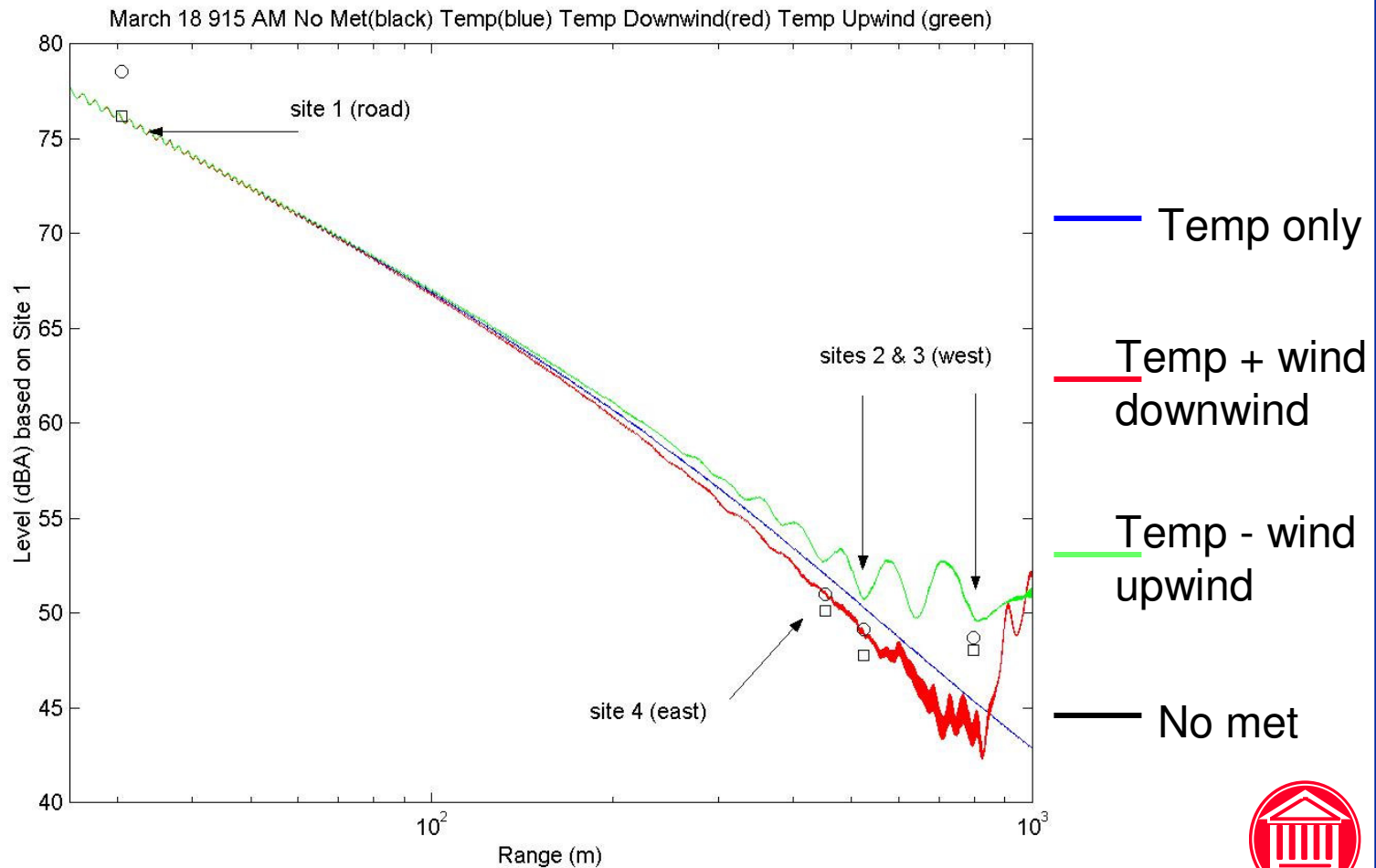
	Spherical $20 \log_{10}(\text{range})$	Typical data No gradient	$15 \log_{10}(\text{range})$	Cylindrical $10 \log_{10}(\text{range})$
Mic2-Mic1	-24.7 dB	-21.2 dB	-18.5 dB	-12.3 dB
Mic3-Mic1	-28.4 dB	-23.5 dB	-21 dB	-14.2 dB



# PREDICTED LEVELS (7:15 AM strong gradient)

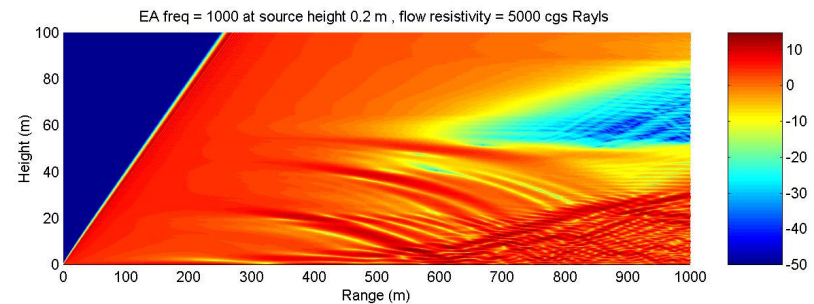
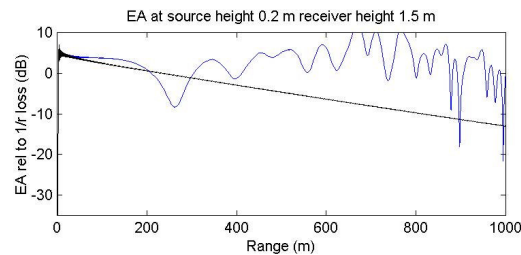
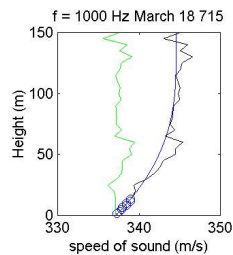
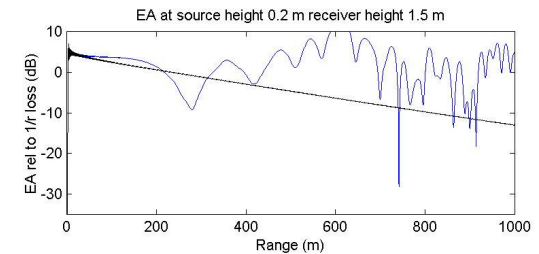
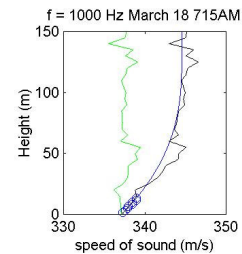


# PREDICTED LEVELS (9:15 AM no gradient)

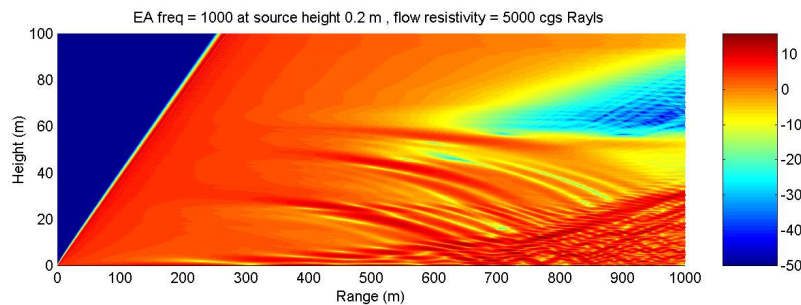


# RAISED JET 5 m (PE)

Slight change in structure  
Energy pushed to  
700 m range



Original

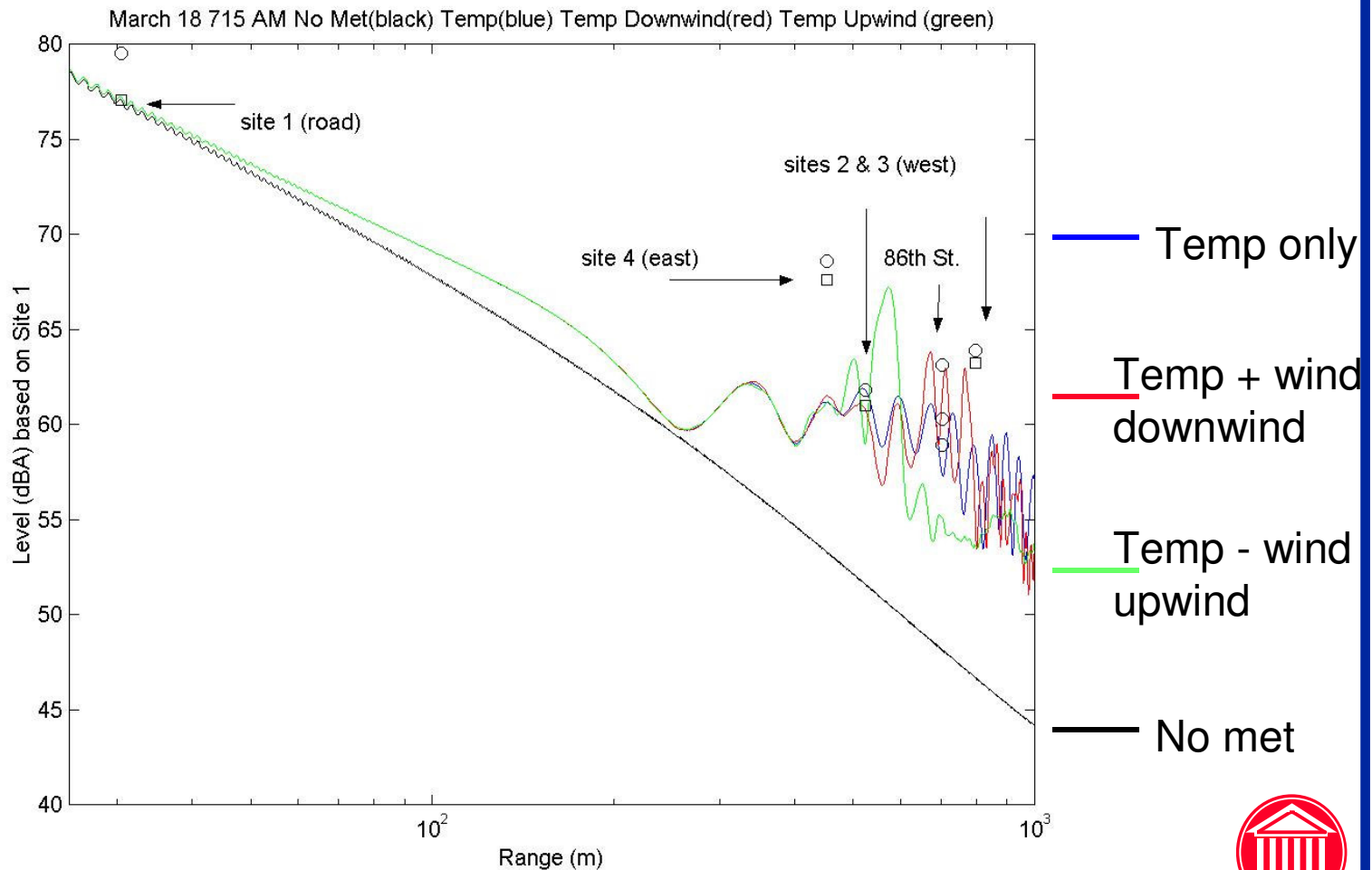


Elevated Jet



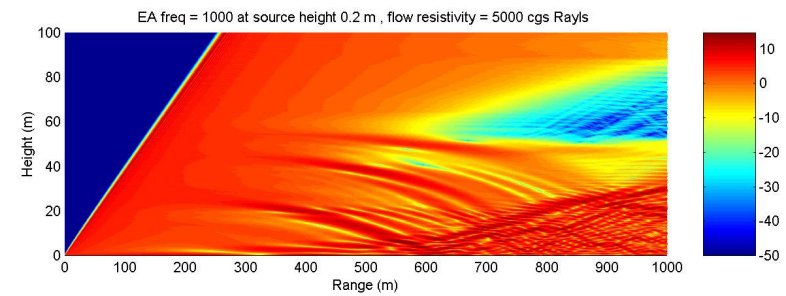
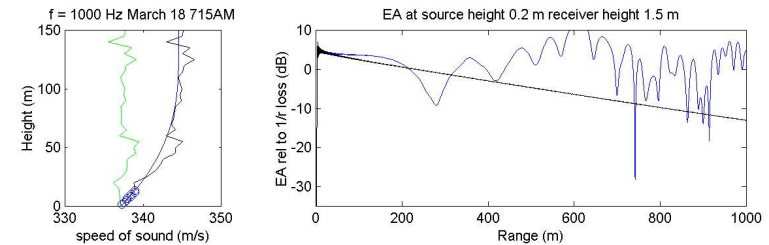
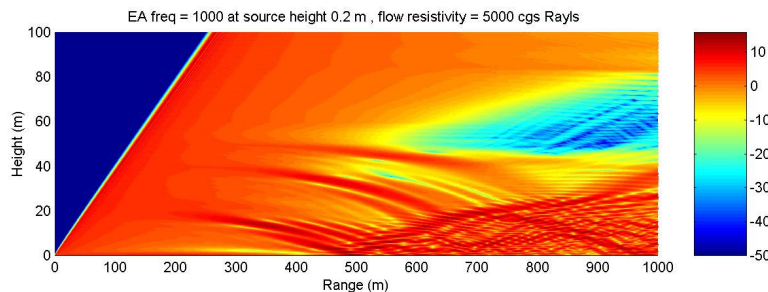
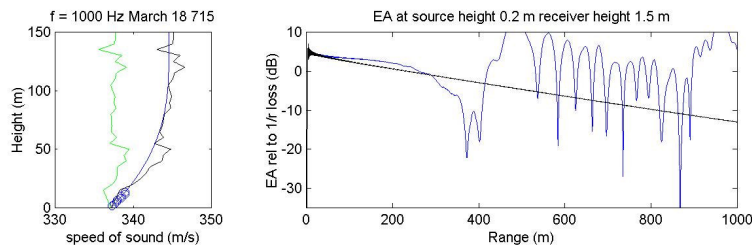
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# RAISED JET 5 m (Predicted levels)



# LOWERED JET 5 m AND DOUBLED SPEED

Slight change in structure  
Energy brought in to  
500 m range



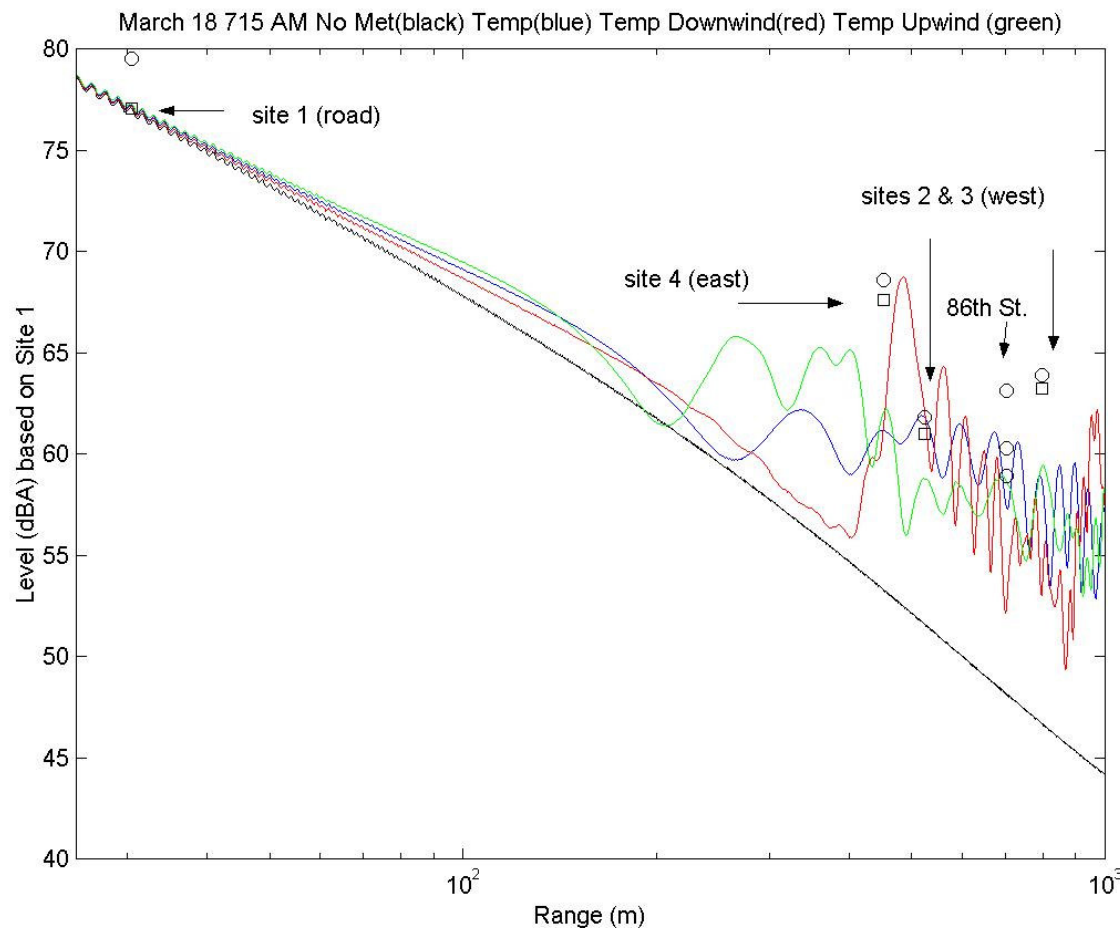
Original

Lower elevation  
higher speed Jet



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# LOWERED JET 5 m AND DOUBLED SPEED



— Temp only

— Temp + wind  
downwind

— Temp - wind  
upwind

— No met

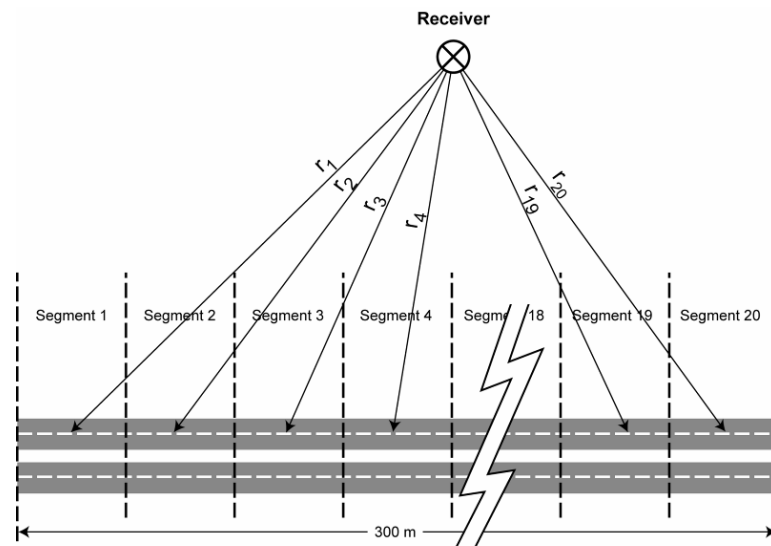


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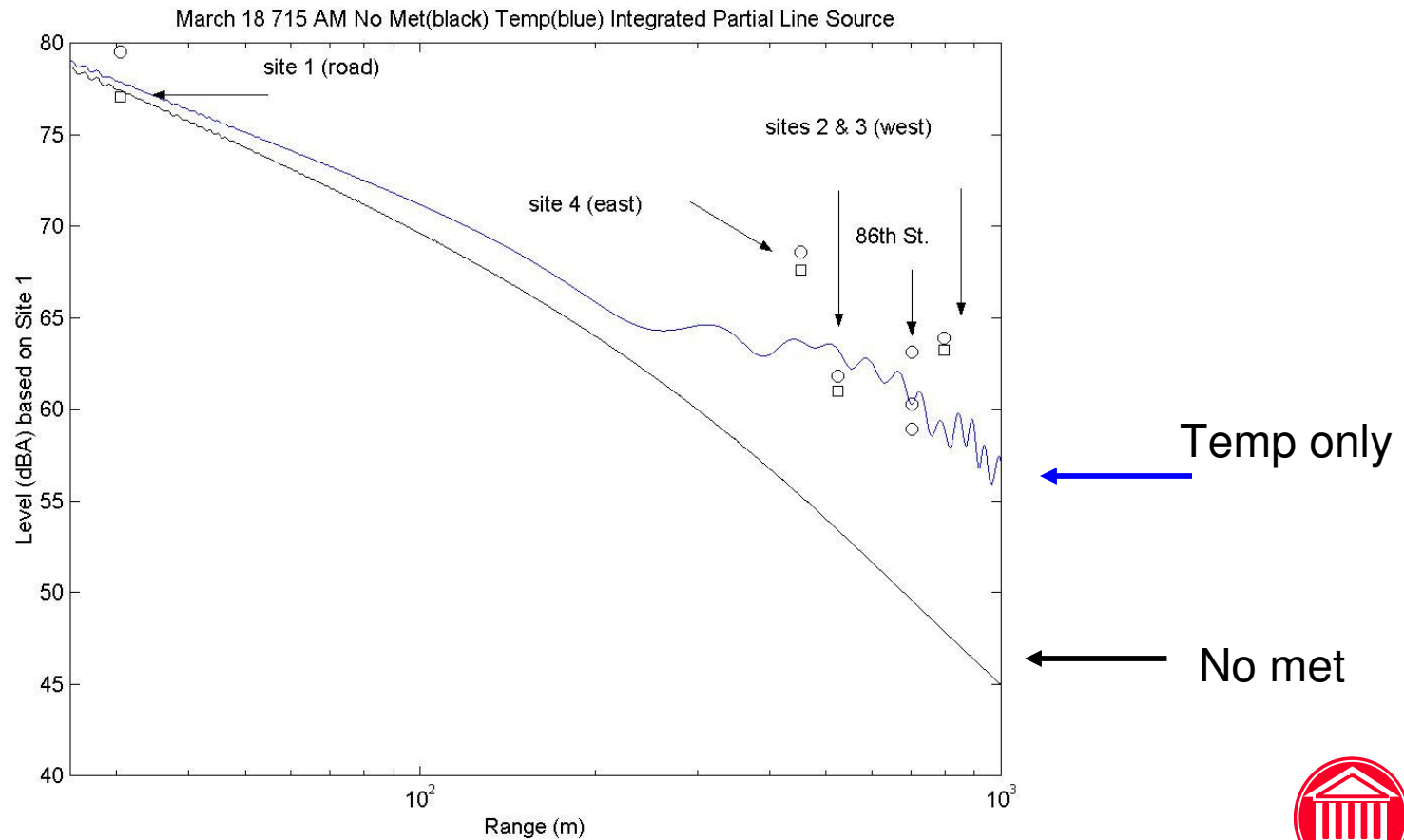


# Finite Length Highway

- Each Section of Highway treated as separate source and run through PE model (ala TNM) and combined incoherently
- Twenty 15m sections used
- Functionally provides the  $15\log_{10}(\text{range})$  effect observed previously

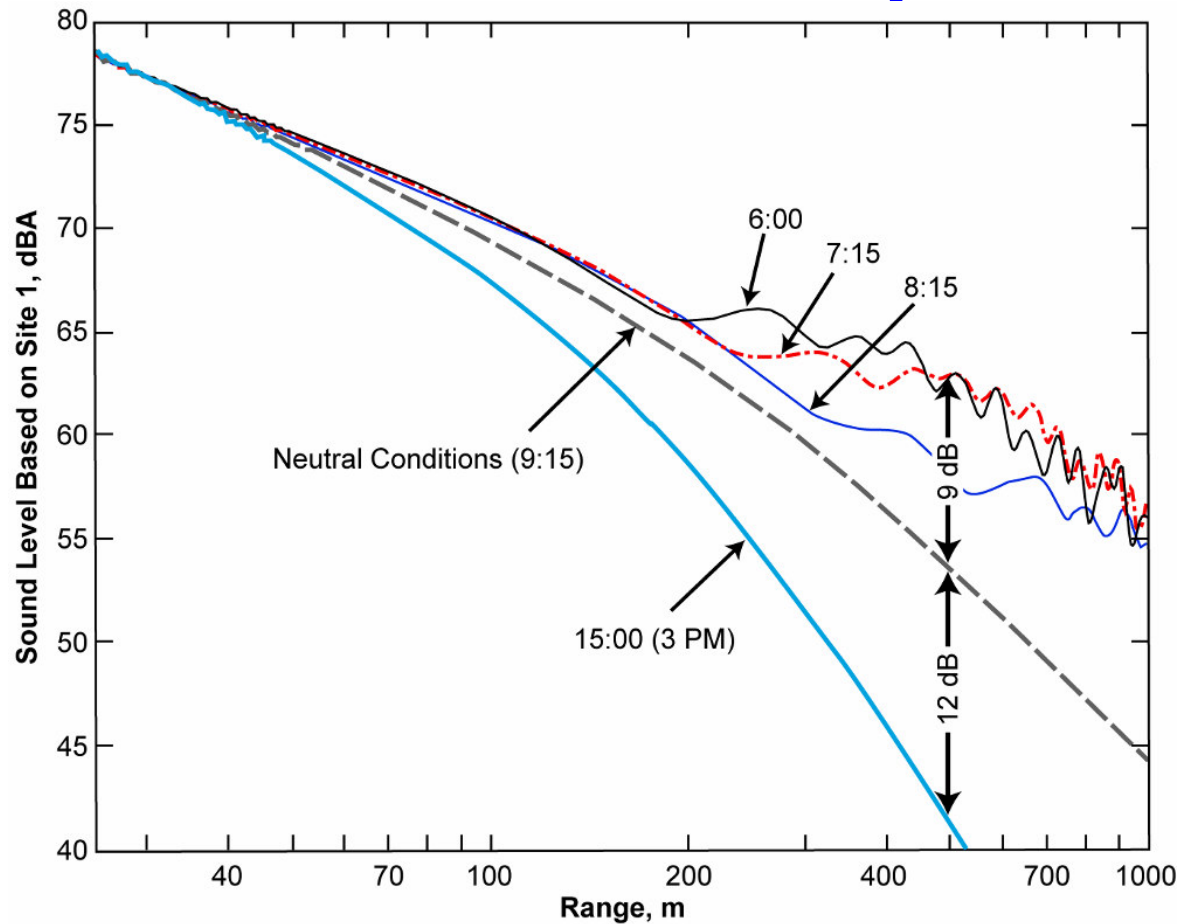


# PREDICTED LEVELS (7:15 AM strong gradient)



# SOME OBSERVATIONS (temp only)

## model output



## CONCLUSIONS

- Inversion cause of increased levels in community
- PE model capable of showing increase or decrease in levels due to meteorology
- Effects of temperature inversion sufficient to explain majority of increased levels (and community complaints)
- Implied effects of light winds (assumed profile) explains perturbations about this elevated level (focusing)
- Region of High absorption near highway (plowed field) possible cause of finite length line source effects





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